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# ARMORED MEDICAL RESEARCH LABORATORY

FORT KNOX, KENTUCKY

INDEXED

First Partial Report

On

PROJECT NO. 17 - PROTECTION OF PERSONNEL IN TANKS AGAINST TOXIC AGENTS

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ARMY GROUND FORCES  
MEDICAL RESEARCH LABORATORY  
Fort Knox, Kentucky

Project No. 17  
File 723.13

7 March 44.

1. PROJECT: No. 17, Protection of Personnel in Tanks Against Toxic Agents. First Partial Report.

a. Authority - Reference 4th Indorsement, Headquarters Army Ground Forces, File 470.8 (21 May 1943) GNRQT-10/44857, dated 1 July 1943, Subject: "Protection of Personnel in Tanks Against Toxic Agents".

b. Purpose - To study the practical usefulness for tank crews of an individual-collective protection system against chemical warfare agents.

2. DISCUSSION:

a. The Canadian Army Chemical Warfare Laboratories have developed a gas-protection system for the Ram Tank series, consisting of a positive supply of purified air through face masks to each crew member and sealing materials for closing hull openings to eliminate entry of liquid agents.

b. The basic plan behind the development of this method of CW protection is based upon two broad principles: (1) to reduce the probability of direct contamination of tank crews by liquid CW agents, (2) to provide a positive supply of decontaminated air for breathing through a facepiece which would be sufficiently comfortable to be worn continuously. Ideally, the facepiece should be preferred for use at all times regardless of the gas hazard, thus eliminating the possibility of casualties from a surprise gas attack.

c. A modified Canadian system has been installed in a standard M4A3 medium tank to observe its function with respect to crew maneuverability protection from dust, stowage requirements and ease of installation. Tests have been conducted to measure the decrease in fighting compartment ventilation due to the closing of openings normally found in the standard M4A3 medium tank. Details of procedure and results are described in the Appendix.

d. This method of protection is not to be considered as a substitute for positive-pressure ventilation of the crew compartment. It is a major interest as a means of providing protection in tanks now in the field, whereas the positive-pressure lends itself particularly to incorporation into new models of tanks.





3. CONCLUSIONS:

a. The sealing materials and the air supply and purifying system are easily installed. The equipment occupies a minimum of space and does not interfere with the stowage of other items. It utilizes a minimum of power (approximately 125 watts).

b. The system of individual respiratory protection was preferred for continuous wear by the crew members in our test and was found not to interfere seriously with crew efficiency.

c. The simple facepiece provides excellent visibility, but the transparent material now used is not highly resistant to abrasion.

d. The system provides protection against gun fumes and dust as well as gas protection, eliminating the need for goggles and respirators.

e. The rate of airflow thru the facepiece must be sufficient to meet the demands of gasping respiration, a maximum rate up to 8 cfm. As compared with the present equipment, a greater rate of airflow and a modified design of facepiece to provide self-sealing during gasping respiration would be desirable.

f. Reduction in crew compartment ventilation due to sealing of openings is negligible, (approximately 7-1/2%). It is anticipated that this will increase the transmission oil temperature over normal operating level about 10 degrees during sustained operation.

g. The system requires the wearing of suitable anti-gas clothing, which will impose an added heat load in hot, humid climates.

4. RECOMMENDATIONS:

a. In view of the present active development of a system of individual gas-protection of U. S. Tanks, similar in principle to the Canadian system, by Ordnance and CWS, no specific recommendations are made. The present report is for information.

(NOTE: The conclusions and recommendations set forth above have been concurred in by Headquarters, Armored Center, W. H. Nutter, Colonel, G. S. C., Chief of Staff.)

Submitted by:

Robert H. Walpole, Captain, F. A.

APPROVED

*Willard Machle*

WILLARD MACHLE

Colonel, Medical Corps  
Commanding

2 Incl.

#1 - Appendix w/tables 1 & 2

#2 - Figures 1 thru 4





## APPENDIX

1. The vulnerability of tanks to attack by chemical warfare agents is generally recognized and has been demonstrated by numerous tests. The ease of penetration of outside contamination into the vehicle results, in part, from the fact that numerous apertures exist in the structure; of greater importance, however, is the method of ventilation which produces an inward air flow through these apertures so that outside contamination is immediately brought into the tank.

2. Field tests, using the major chemical weapons and agents\* have established two important facts which must be kept in mind in the development of gas-protection means:

a. In the standard tank, gas is brought immediately into the crew compartment from an outside nearby source. Against potential ambush attack with rapid-acting agents such as HCN, it is therefore essential that the means for crew protection against CWA be capable of continuous operation so as to maintain protection at all times in combat areas where chemical attack is anticipated.

b. Entry of liquid agents into the standard vehicle is relatively easy and effective protection against liquid vesicants in addition to gas and vapor protection is essential.

3. For the protection of the tank crew against chemical agents, consideration has been given to two basic methods: (1) individual protection and (2) protection of the tank as a whole. The first involves the supply of purified air to each crew member either by personal respirator or from a central canister together with the use of anti-gas clothing and sufficient sealing of apertures to minimize liquid entry. The second requires effective sealing of the apertures in the hull and turret of the tank and the installation of a positive-pressure system of ventilation for the crew compartment, the air being supplied through a suitable purifying canister.

4. Armored Medical Research Laboratory and Chemical Warfare Service reports discuss the merits and limitations of the positive-pressure ventilation method of gas-protection. The degree of protection afforded by the individual protective system has been reported by the Chemical Warfare Laboratories, Ottawa.\*\*

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\*AMRL Sub-Project No. 3-9, Second Partial Report, Determination of Ventilation for Gas-Proofing Tanks of the M-4 Series; 23 June 1943. CWS Report T.D.M.R. No. 52, Project D4.1-11 Field Tests of a Pressure Ventilation M4A3 Tank Equipped with Air Purification System, dated 18 October 1943.

\*\* CWL Report No. 12, Protection of Tank Crews Against CW Agents. Chemical Warfare Laboratories, Ottawa, Canada, 1 August 43.

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5. The present report deals with some preliminary observations upon the function of the individual protective system, as developed in Canada. The equipment, which was designed for field installation, was installed without difficulty in an M4A3 tank.

6. The protective kit consists in two units: (1) the air purification and supply system and (2), sealing materials for tank apertures. The latter includes sponge rubber gaskets, cement, tape, etc., to be fitted around hatches, pistol port, periscopes, gun openings for protection against entry of liquid vesicants discharged from such weapons as squirt, grenade, bomb, or land mine.

7. The second part of the kit includes two air supply and purification units, one to serve the two crew members in the bow, the other to serve the turret members, thus eliminating the need for complicated pipe connections between the two compartments. Each system consists of the following pieces of equipment.

a. Filter for protecting the blower and gas canister from dust.

b. Air supply fan driven by an electric motor. Capacity of the blower is dependent upon the number of men it serves, 4 to 6 cubic feet of air per minute per man being required.

c. Junction box to distribute air from blower to crew members.

d. Canister boxes (See Fig. 4) containing two standard service mask canister modified with slots cut in one side of each for air intake. There is one canister box per man in the air filtration system.

e. Facepieces (See Fig. 2) consisting of lightweight flexible leather frame, holding a full vision replaceable celluloid front which snaps in place. The mask fits relatively tightly against the chin and cheeks but is loose at the forehead. Air enters the mask below the chin, passes over the face and out through the space at the top.

f. Necessary hose and joints for connecting the above pieces of equipment.

8. The filter box is fitted into the existing ceiling ventilator to receive outside air. The air is cleaned by the filter and is then distributed through the junction box to the two or three canister boxes, and thence to the individual facepieces. The unit devices are all installed on the ceiling or sides of the tank in accessible locations, and do not interfere with present stowage requirements. Air supply hoses of the required lengths are suspended from the ceiling where necessary so as not to interfere with the movements of the crew members.

9. Figures 1, 3 illustrate the facepiece and its adaptation for use with a tank crash helmet. The design of the facepiece readily permits the use of the lip microphone now employed in the interphone communication system.

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FOR THE YEAR 1900

CHICAGO, ILL., 1901

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10. Sealing of openings around the guns, hatches, periscopes, etc., was readily effected by means of the field kit items, the installation being made without difficulty. Since this sealing causes a reduction in air flow through the fighting compartment there was some question of an excessive temperature rise in the transmission oil which is cooled by the air passing through the radiator located in the bulkhead. Comparative air flow measurements made in a standard M4A3 medium tank and in the M4A3 with openings sealed are shown in Table I. The rate of ventilation is reduced only 7-1/2% and the Canadian tests show a minor rise in oil temperature of approximately 10°F over the standard operating temperature.

11. Operational tests have been conducted to observe crew efficiency with the air filtration system installed and in operation (See Fig. 3). These tests were conducted with the tank open and "buttoned up". The reaction of the test crew members was that they would prefer wearing the facepiece even in the absence of gas because of the exclusion of dust and the pleasant cooling effect on the face. There was no interference with their movements in the tank. No test was made at extremely low air temperatures. Heating of the air may be necessary under such conditions.

12. The facepiece was found to fog from exhaled air during operations at relatively low temperature and high humidity. This may be reduced by the application of a baffle for deflecting expired air, the use of a check valve in the facepiece, or both. Consideration should be given this in the final design of the equipment.

13. The use of this method of gas-protection is not limited to tanks. It can be incorporated in all types of armored vehicles although there is no possibility of protection from liquid vesicant contamination in open vehicles except by means of protective clothing.

#### 14. Operations in hot climates.

a. Since there is no exclusion of gases and vapors from the crew compartment, this system of protection requires, in addition to the respiratory protective mask, the use of anti-gas clothing suitably treated to exclude vesicant vapors. Such clothing is known to impose an added heat load on the wearer. Hence, the use of this overall method of protection may have limited application for continuous operation in hot, humid climates. The magnitude of the added heat load in a jungle atmosphere is indicated by the following summary of tests on two men fully acclimatized to jungle heat who walked for 47 minutes at a rate of 2-1/2 mph, carrying a 20 pound pack (Table 2). The increase in pulse rate, rectal temperature and sweating rate in the jungle atmosphere over performance in the comfortable environment was several-fold greater with the anti-gas suit than when wearing the regulation fatigue suit. At the end of the work period the men are near the point of exhaustion in the one case and only mildly fatigued in the other. These data indicate that for the extreme jungle conditions, at least, the extra heat load imposed by the protective clothing is intolerable for continuous use. It may be pointed out that while the humid atmosphere employed in these tests is perhaps in excess of actual jungle conditions, it may more nearly represent the condition inside a tank operating in the jungle.





RATES OF VENTILATION THROUGH  
FIGHTING COMPARTMENT  
Standard and Sealed M4A3  
Medium Tank

Engine RPM	Standard M4A3		Modified M4A3	
	Negative Pressure	Air Flow Cfm	Negative Pressure	Air Flow Cfm
500*	0.06"	300	0.06"	270
800	0.13"	470	0.17"	440
1000	0.20"	590	0.27"	550
1200	0.29"	700	0.41"	650
1400	0.38"	820	0.57"	760
1600	0.49"	940	0.73"	870
1800	0.64"	1060	0.90"	980

\* Idling Speed

TABLE 1

*Incl #1*





TABLE 2

COMPARATIVE PERFORMANCE OF TWO MEN DOING STANDARDIZED WORK<sup>#</sup>  
 IN COOL AND JUNGLE ENVIRONMENTS--REGULATION FATIGUE  
 UNIFORM VS. IMPREGNATED ANTI-GAS SUIT.\*

Environment	Clothing	Pulse Rate		Rectal Temperature		Sweat Loss	
		BPM	Increase	°F	Increase	Gms/hr.	Increase
Cool $t_d = 57^\circ$ ; R.H. = 60%	Fatigue	93	-	99.9	-	183	-
Jungle $t_d = 91^\circ$ ; R.H. = 95%	Fatigue	110	17	100.0	0.1	755	572
Jungle $t_d = 91^\circ$ ; R.H. = 95%	Anti-gas	150	57	101.4	1.5	1415	1232

# Comparable to work level in tank driving.

\* Included: Union Suit, cotton, one-piece, protective  
 Suit, HBT, one-piece, protective  
 Socks, wool, light, protective  
 Hood, wool, O.D., protective  
 Gloves, cotton, protective

Not worn: Leggings, canvas, M1938 O.D., dismounted, protective  
 Shoes, impregnated, M-1  
 Gas Mask

TABLE 2

chuck #1







FIG. 1  
FACEPIECE, FRONT VIEW, WITH TANK CRASH HELMET  
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FIG. 2  
FACEPIECE, SIDE VIEW

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**FIG. 3**

**TANK DRIVER WITH FACEPIECE**

**A.G.F. MEDICAL RESEARCH LABORATORY**

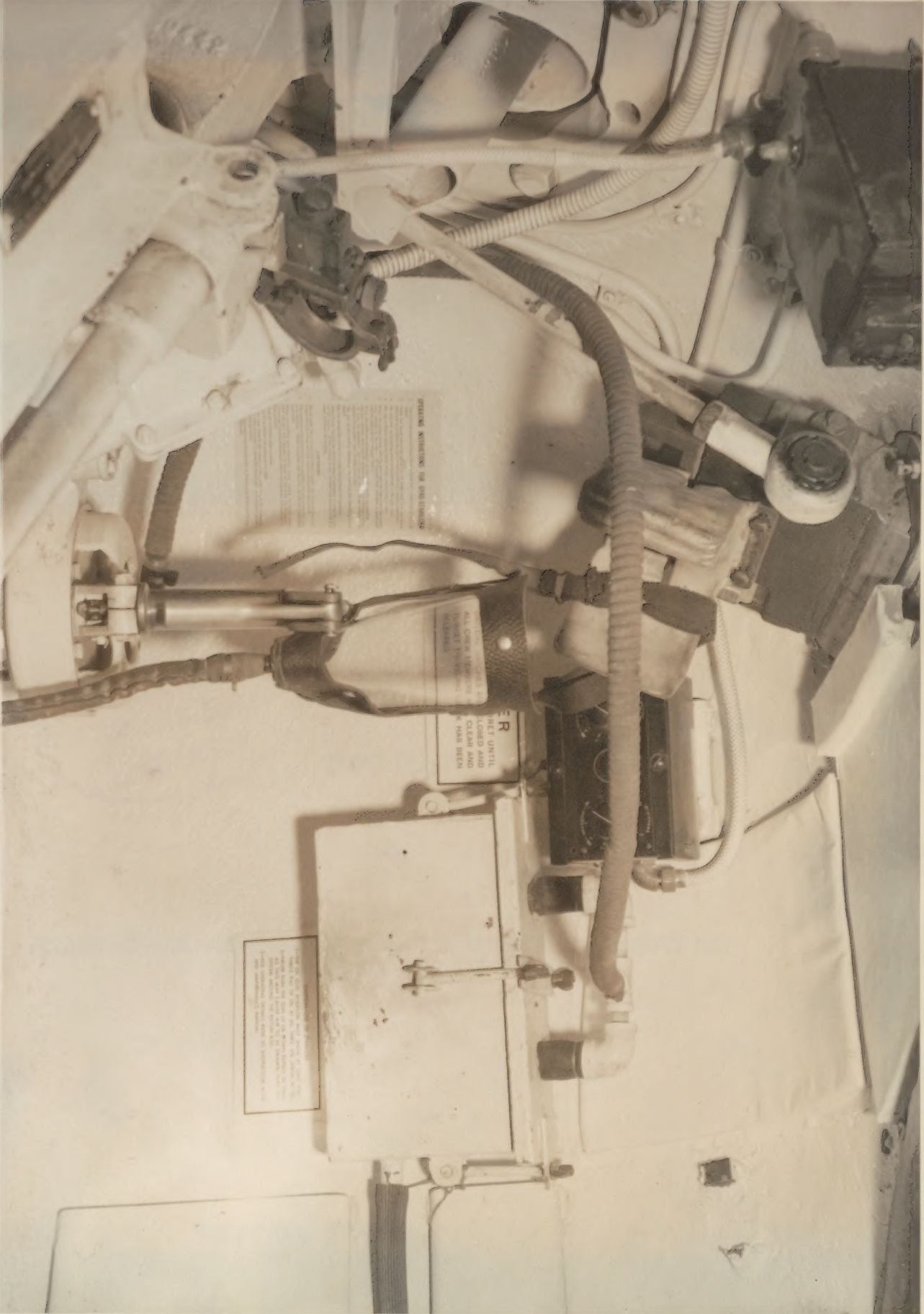
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**FIG. 4**

**CANISTER BOX**

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